HIGH-RESOLUTION FORAGING BEHAVIOR AND MOVEMENT PATTERNS OF STELLER SEA LION JUVENILES IN REGIONS OF STABILITY AND DECLINE

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Semi-Annual Project Report

PROJECT SUMMARY:

The ongoing decline in the western population of Steller sea lions (*Eumetopias jubatus*) has placed marine mammal management in direct conflict with several important commercial fisheries, and has focused attention on identifying habitat and prey resources critical for population survival. Research into the causes of the decline has focused largely on two factors: reduced prey availability (due either to fisheries competition or environmental change) and/or declines in the survivorship of juveniles - the age class most susceptible to changes in the prey landscape due to their lack of foraging experience, smaller size, and reduced dive capacity. Determining how juvenile sea lions select foraging locations and make foraging decisions in light of biological and environmental conditions is critical if we are to understand how changes in fish abundance will impact condition and survival. It is also critical if we are to assess when in the year juveniles are most sensitive to prey availability, where juvenile foraging takes place, and whether differences in population trajectories are correlated with variation in individual foraging effort.

While several management actions have been taken based on assumptions about how sea lions utilize their habitat, to date the data collected has been unsuitable for use in the fine-scale analysis techniques that are most appropriate for addressing the above issues. However, recent advances in tag technology now make it possible to outfit juvenile sea lions with small, high-resolution instruments that collect and transmit the highly detailed dive data necessary to determine how individual animals manage their time and energy resources when foraging. In addition, we will receive many, high quality locations from tagged animals, which in turn will allow us to construct habitat use maps with much greater spatial and temporal resolution. The need for more detailed information on how Steller sea lions select and utilize foraging grounds, and the absence of the high-resolution dive data necessary to do this has been highlighted by the recognition that the Western population decline is not uniform, and that counts around in the Dutch Harbor area are increasing.

Therefore this project is designed around using high-resolution SRDLs deployed on juvenile in area of decline and increase in order to collect the data necessary to address the following hypotheses: 1) that Steller sea lion juveniles in both regions select foraging areas with particular environmental features likely to aggregate prey resources; 2) that juvenile sea lions diving in regions with recently declining and increasing counts demonstrate different foraging behaviors and effort; and 3) that differences in foraging behavior and habitat use of Steller sea lion juveniles are correlated with age, nutritional and/or physiological status.

In addressing these hypotheses, this research will enable us to link biological (prey composition, distribution, and abundance) and physical characteristics of the foraging environment (temperature, bathymetry, location) with the foraging behavior and strategies of sea lions. These links can be built at a much finer scale than previously due to the use new technology, and so can provide detailed 3-dimensional maps of sea lion habitat use patterns in regions where populations are increasing and decreasing. In particular, we hope to determine whether juveniles in the declining population must work harder (as judged by dive duration, frequency, or pattern) in order to find prey resources.

Progress towards these research goals and our performance measures are shown in **Table 1**, and are detailed in the narrative report below.

TAG DEPLOYMENT SUMMARY

Tags have been designed and programmed, and to date we have participated in three cruises with ADFG and/or NMML. The first cruise was in Prince William Sound in November, the second was to Kodiak Island in March, and the third to the Aleutian Islands in May. We outfitted two juvenile sea lions with SRDLs in November in order to test programming parameters and attachment methods. In March we outfitted five pups with SRDL tags, but were unable to locate and capture any juveniles. In May we were not able to capture any juveniles, and so did not deploy any tags. We were unwilling to tag more nursing pups because we did not feel that this age class was suitable for addressing questions about foraging patterns. A summary of the deployments is in Table 2.

The initial deployments have gone well. While some tags have stopped working earlier than expected, the first two test deployments lasted for more that 3 months each, and returned good data. The recent resightings of these animals has highlighted the need to reinforce the antenna to prevent loss through wear, and redesign is currently underway. The deployments of pups in March also went well, with one tag still functioning. We were concerned that pups would show little useful diving, but the tags that lasted through May did report interesting behavior across the spring pupping period. It may be that we can identify weaning from shifts in behavioral patterns.

MOVEMENT PATTERNS

The tags are working extremely well with respect to animal locations. We receive multiple locations a day (on average >10/d), and have received many 'at-sea' locations. We are able to use this data to identify haul-out sites, movement routes, and at sea foraging locations. However, because movements are so short in distance, relative to the error associated with position fixes, we will need to carefully screen the recovered data. We are testing several currently available screening algorithms, and are developing some of our own that are more suited to otariid data.

Most of the sea lions tagged as part of this project have remained near the site of original capture (Figure 1). There have been two notable exceptions:

1. After being tagged at Perry Island in early November, Lindy moved to Glacier Island (~45km) in late December,
2. Cliff moved a distance of 580km over a one-month period beginning in late April. Until then the animal had remained at Two-Headed Island where it had been tagged, but on 4/24 it undertook a month-long series of movements to Hook Point (Hitchinbrook Island), with intermediate 1-3 day stays at Gull Point, Cape Chiniak, Marmot Island, Outer Island and Cape Hitchinbrook. The animal made a 3-day excursion to the Continental Shelf between Outer Island and Cape Hitchinbrook.

Two other animals made short excursions away from the site of initial capture, but returned later:

1. Within 1 day of release on March 3rd at Long Island, Prop moved 55 kilometers NE to the Marmot Island haulout, and remained there until April 17, when it returned to Long Island for the duration of the deployment.
2. Helen remained at Two-Headed Island from tagging on March 5th until April 12, when she traveled ~40 kilometers SW to Sitkinak Island, where she remained until May 4th. She then returned to Two-Headed Island.

With the exception of the above movements, all animals remained close to shore and only made short distance trips offshore. Perry showed the clearest pattern of foraging trips: he made regular circuits between the haulout and several reefs and islands 7-9 kilometers to the north-northeast and used Perry Island as a central-place haulout throughout the deployment (Figure 2). In transit Perry crossed a 2-5 km wide trench of 150-350 meter depths, and many of the dives during his offshore diving bouts were between 140-170 meters (Figure 3).

DIVING PATTERNS

The tags have worked extremely well given the behavior of the animals. Given the transmission constraints, the more short and shallow dives that a sea lion makes, the less complete the dive record will be. On average, the tagged sea lions have made many dives, most of which were short and shallow. Yet, despite this behavioral pattern, we have received good coverage in the dive records. Records are more complete for the older animals tagged in PWS, and are more complete in older pups (animals < 1yr) due to the above constraints. However, we have received more data than expected, and will be able to analyze foraging behavior in depth using the detailed records received.

To summarize the data recovered: to date we have recovered data from 26,612 dives. On average, dives were shallow (< 25m) and short (<90s). Most dives occurred during the day, and animals typically hauled out at night. In general the 17mo old sea lions dove deeper, longer, and more frequently than did the pups (9 mo). Values for individual animals are shown in Table 3.

While there was little seasonal trend in the depth or duration of dives made by animals tagged in Prince William Sound in November, the physiological data obtained from ADFG researchers, suggests that these two animals were weaned at the time of capture, or at least s supplementing their diet with fish. Our diving records support this hypothesis. The 5 pups tagged at Kodiak were likely still suckling at the time of their capture, and their dive data indicated an increase in dive depth and duration as the spring progressed (Figure 4). This suggests that pups begin to increase their diving effort as they approach the end of their first year. The change occurred in late April / early May, when lactating females are returning to the breeding rookeries, and investing considerable energy in their late term fetus. It is possible that the pups were weaning at this time.

COMPARISONS BETWEEN STOCKS

With the limited data yet available it is impossible to assess whether there are differences in the diving patterns of animals in the east vs. west stocks. For all metrics (dive depth, duration, frequency) analyzed so far, the Prince William Sound animal values exceeded those from the Kodiak region (Table 4). While this is likely due to the older age and larger size of the PWS SSLs, it could also be due to differences in season or location.

CORRELATION WITH OCEANOGRAPHIC FEATURES

We have not yet correlated movement or behavioral patterns with external datasets

PLANS FOR 2002

1. Currently, tags are being redesigned to include a more robust antenna, and to be able to transmit temperature depth profiles. Those tags will be available for deployment in September and November.
2. We hope to deploy another 17 tags by the end of the year.
3. Development of data analysis routines
4. Integration with oceanographic and habitat variables

TABLE 1: EVALUATION OF PROJECT OUTCOMES

Objectives	Performance Measures	Progress
Deploy tags on Juvenile Steller sea lions in regions of count increase and count decline.	Number of tags deployed in each region Successful recovery of data from those tags.	7 tags have been deployed Data recovered from them for periods ranging between 14 - 123 days
Map juvenile Steller sea lion foraging habitat	Generate habitat use maps Separate sections of travel from foraging	Done for each animal In progress
Characterize sea lion foraging habitat with respect to its physical and/or biological features	Acquire physical and biological oceanographic data from remote sensors, the GAP project and NOAA fisheries surveys, and integrate into GIS modeling framework.	Coordinated with GAP and NOAA Redesigned SRDLs to include temperature measurements Developing framework to incorporate RS data
Determine juvenile diving behavior in two regions	Determine a suite of dive parameters for each tagged sea lion	Dive performance measured for all tagged sea lions Sample size currently too small for comparisons
Compare patterns of foraging habitat use between sea lions in regions of increase and decline	Construct optimal foraging models that relate patch residence time to travel time. Compare model outputs between regions to determine if sea lions allocate time differently between two activities.	Sample size currently too small for comparisons
Determine if differences in foraging habitat and behavior impact juvenile health or condition.	Determine health and condition measures for each tagged sea lion.	Health parameters have been measured, physiological capacity measurements await permits

TABLE 2: SUMMARY OF TAGS DEPLOYED TO DATE

Animal ID	Age	Sex	Location Tagged	Tag Date	Duration Tagged
280PWS01 "Perry"	17 mo	M	Perry Island, Prince William Sound	11/9/01	99 days (until 2/16/02) animal sighted alive on 5/2/02. Tag had broken antenna
286PWS01 "Lindy"	17 mo	F	Perry Island, Prince William Sound	11/10/01	123 days (until 3/12/02) Animal sighted alive on 5/2/02. Tag had fallen off
W594 "Red"	9 mo	M	Long Island, Kodiak	3/2/02	14 days
W596 "Prop"	9 mo	M	Long Island, Kodiak	3/3/02	75 days
W599 "Fraser"	9 mo	M	Long Island, Kodiak	3/4/02	Still transmitting
W685 "Helen"	9 mo	F	Two Headed Island, Kodiak	3/5/02	62 days
W688 "Cliff"	9 mo	M	Two Headed Island, Kodiak	3/5/02	81 days

Animals tagged in Prince William Sound were in cooperation with ADFG, those tagged in Kodiak were in cooperation with NMML

TABLE 3: SUMMARY DIVE STATISTICS FOR EACH SEA LION TAGGED

Sea Lion	Dive Depth (m)	Dive Duration (s)	Dive Frequency (dives/d)	% time in water
280PWS01 "Perry"	38.1 (225.3)	121.6 (488)	116	41.4%
286PWS01 "Lindy"	13.9 225.3	83 328	163	39.3
W594 "Red"	7.3 13.5	34.3 128	22.5	18.0
W596 "Prop"	10.8 51.8	62.7 224	26	26.6
W599 "Fraser"	11.9 98.3	62.5 240	229	51.9
W685 "Helen"	10.5 54.8	52.8 296	79	42.5
W688 "Cliff"	13.8 146.3	61.2 328	113	45.4

TABLE 4: COMPARISON OF DIVING PATTERNS BETWEEN ANIMALS TAGGED IN NOVEMBER AND MARCH. AVERAGE AND (MAXIMUM) VALUES ARE SHOWN.

Stock	Mean % time hauled out	Mean Dive Depth (m)	Mean Dive Duration (s)	Dive Frequency (#/d)
Aleutians (March 2002)	66.9 + 5.2 (SD)	12.0 (146)	60.0 (328)	133.5
PWS (Nov 2001)	59.7 +1.0	35.1 (225)	130.4 (856)	136.9

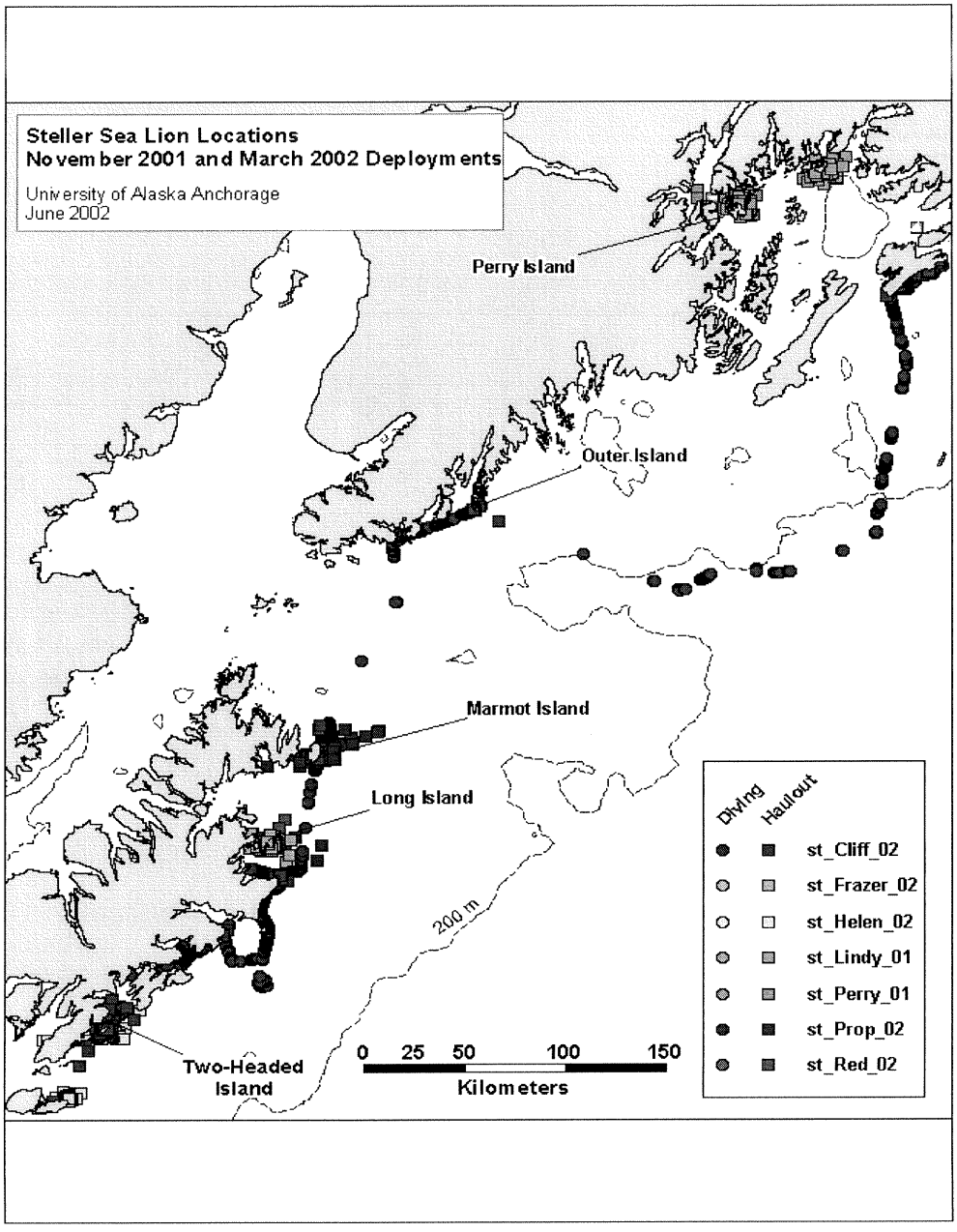


FIGURE 1: MOVEMENTS OF ALL TAGGED SEA LIONS

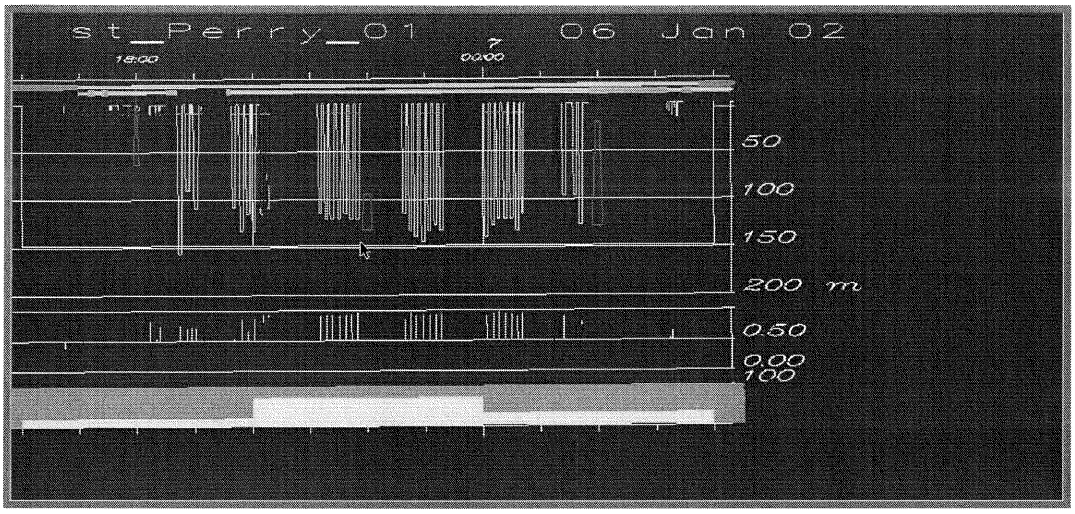
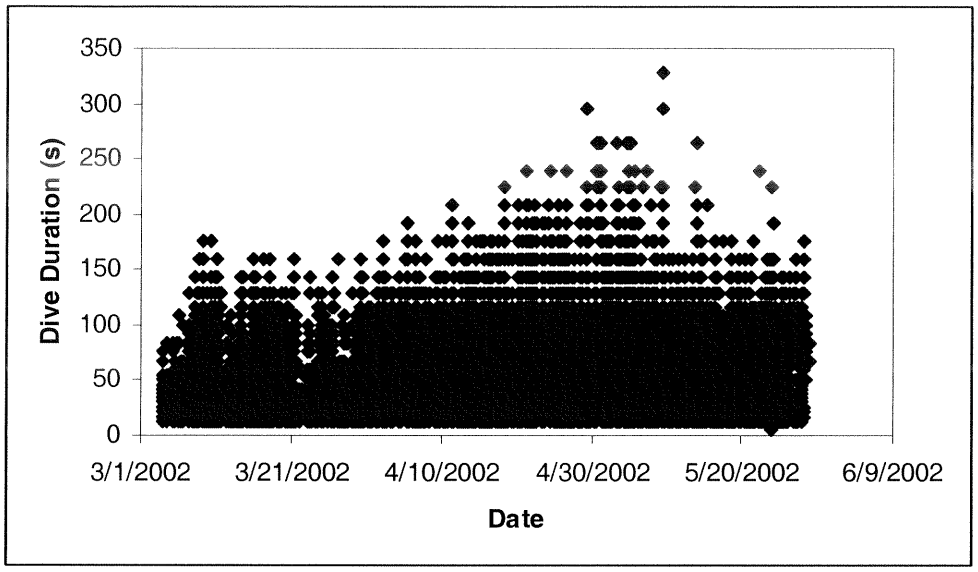


FIGURE 2: DIVING DATA FOR PERRY DURING ONE OF HIS TRANSITS AWAY FROM THE PERRY ISLAND HAULOUT

FIGURE 3: ONE ROUND-TRIP FOR PERRY FROM PERRY ISLAND TO THE FORAGING LOCATION



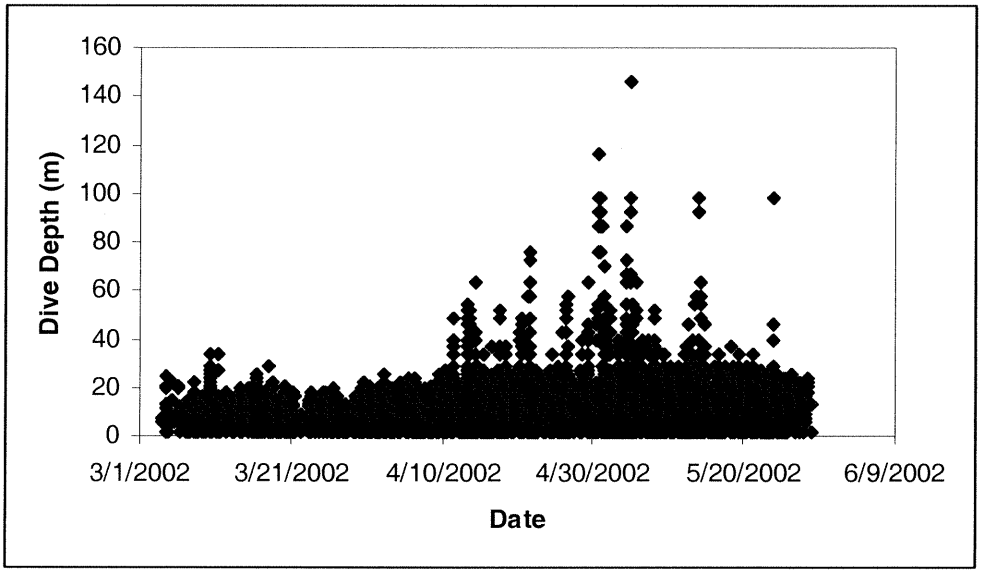


FIGURE 4: **DURATION (S) AND DEPTH (M) OF DIVES MADE BY PUPS TAGGED IN MARCH 2002 AROUND KODIAK ISLAND**